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ABSTRACT

This paper focuses on how microcomputer technology can be used to manage individualization that is based on student differences in cognitive style. Generalized approaches to individualization and the management of individualization are discussed, along with specific approaches based on individual differences in cognitive style variables. Benefits from the use of computers for the management of this type of individualization and the requirements for management with microcomputers are presented. A discussion of practical issues and implications to be considered in an implementation of this approach concludes the paper. Twenty-five references are listed. (Author/LMM)

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Cognitive Style and Microcomputers: Instructional Management Potentials

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Abstract

This paper focuses on how microcomputer technology can be used to manage individualization that is based on student differences in cognitive style. Generalized approaches to individualization and the management of individualization are discussed, along with specific approaches based on individual differences in cognitive style variables. Benefits from the use of computers for the management of this type of individualization and the requirements for management with microcomputers are presented. The paper concludes with a discussion of practical issues and implications to be considered in an implementation of this approach.

Cognitive Style and Microcomputers: Instructional Management Potentials

The success of any individualization approach in large part depends on how well the process of matching individuals with alternative treatments can be managed. This paper focuses on how microcomputer technology can be used to manage individualization that is based on student differences in cognitive styles. Although this topic has general relevance to the management of individualization based on measurable student differences on a variety of dimensions, attention will be given to considerations that can be derived from the growing body of research on cognitive styles and its implications for the management of individualization. As background to this topic, a generalized approach to the management of individualization, traditional approaches to instructional management based on cognitive style differences, and benefits from the use of computers for the management of this type of individualization are described. The final sections of the paper describe the possibilities and requirements for the management of individualization with microcomputers and the practical issues and implications to be considered in an implementation of this approach.

Generalized Approach to the Management of Individualization

In defining the approach to be taken to the management of individualization, including one based on cognitive styles, two component processes must be specified: the approach to individualization and the approach to the management of this defined individualization process. The past decade has seen significant progress in the articulation of general approaches in both these areas, such that it is possible to describe well-defined and evaluated procedures.

Beginning with the first component, specification of the individualization approach, the approach defined by McCombs and McDaniel (1981) and Parkhurst

and McCombs (1979) provides a basis for the following generalizable working model. This model consists of the following steps:

1. Analyzing the student population to identify characteristics related to success/failure in mastering course objectives;

2. Selecting or designing individual difference measures to assess student characteristics identified as important in step 1;

3. Administering selected individual difference measures to the target population in order to analyze reliability and predictive validity, using course performance variables of interest as criterion variables (e.g., test scores, failure rates, learning times, etc.);

4. Identifying best predictors of student performance with current instructional approach;

5. Defining alternative strategies/treatments for accommodating identified student differences;

6. Specifying the individualization approach, including types of decision rules and procedures to be used in individualized assignment to defined treatments;

7. Developing alternative treatments and randomly administering them to the student population;

8. Evaluating alternative treatments and deriving selected decision rules;

9. Implementing alternative treatments per derived decision rules and procedures; and

10. Evaluating decision rule performance and revising as necessary.

The end result of the foregoing process is a validated individualization approach. Ideally, it is at this point that individualization can be implemented on a full-scale basis, thus necessitating the need for an approach to the management of this individualization process. That is, a systematic procedure must be defined for moving students through the individualized program and keeping track of their

performance and progress. In defining the management approach, decisions need to be made concerning the degree to which ongoing research and evaluation will be supported during full-scale implementation. This would allow the management system to be structured such that data required for research and evaluation can be routinely collected along with data used for the management of student performance and progress. Bozeman (1979) discusses several other factors to be considered when defining the management approach, including resources available (e.g., availability of staff personnel or computers to perform management functions), administrative support (e.g., commitment of upper level management to the individualization approach), staff attitudes and competence (e.g., staff's perceived need for individualization and resulting need for staff development/training), and a variety of environmental factors (e.g., size of school, number of courses to be involved, etc.).

Regardless of the sophistication of the designed management system and the degree to which it supports research, the general procedures to be accommodated in the management of individualization include (1) administration and scoring of individual difference measures, (2) diagnosis of student characteristics and prescription of specific treatments or strategies, (3) monitoring and evaluation of student performance on selected treatments, and (4) formatting of data into necessary reports for both student and instructor/researcher. These procedures are particularly well-suited for implementation with computer-based technologies.

For example, Bozeman (1979) describes how the conceptual model of computer-managed instruction (CMI) can be used to assess instructional outcomes, update records, identify instructional needs through reports, and group students

for instruction based on specified individual difference characteristics. McIsaac and Baker (1981) maintain that microcomputers provide an effective way to implement CMI because they are less costly, provide more direct control, and allow better user access and convenience than large mainframe, timesharing systems. More will be said about the use of microcomputers for the management of individualization in the following sections. For now, however, the discussion focuses on traditional approaches to individualization and the management of individualization based on cognitive style differences.

The Management of Individualization Based on Cognitive Styles

Up to this point, the topics of individualization and the management of individualization have been treated in a general way. Recent research indicates that individualization can be maximized by using information about cognitive sytles, sometimes more broadly referred to as learning styles (e.g., Cosky, 1980; Dunn & Dunn, 1979; Gregorc, 1979; Hunt, 1979; Keefe, 1979; Lindelow, 1983; Wardell & Royce, 1978; Whitley, 1982). Whatever term is used, it is clear that styles provide a theoretically based, multivariate method for adaptation to individual differences. Styles include student differences in cognitive, affective, and physiological characteristics or ways of perceiving, analyzing, interpreting, and responding to learning situations (Cosky, 1980; Lindelow, 1983; Wardell & Royce, 1978).

Researchers applying individualization approaches based on cognitive or learning styles have generally handled the management of this individualization with manual, teacher-based procedures. That is, they have implemented manual procedures for administering and scoring cognitive style inventories, compiling scores into student profiles that can be matched with alternative treatments,

assigning students to these treatments, and administering appropriate post-tests and remediation. Examples of these individualization approaches include Hunt's (1979) implementation of a Conceptual Level Matching Model for matching students' stages of development and present styles to specific teaching approaches that differ in degree of structure; Anderson and Bruce's (1979) practical application of a plan for matching learning and teaching styles in a high school setting; and implementations of treatment matching approaches based on cognitive styles in an elementary school setting (Ellis, 1979; Epstein, 1981). In each of these examples, the primary responsibility for diagnosing, prescribing, implementing, and evaluating the individualization rested with the teachers.

A number of other applications of individualization based on cognitive styles have used a cognitive mapping approach wherein Hill's (1975) Cognitive Style Inventory provides a cognitive learning style profile that can be used to specify the conditions under which a student can best learn (e.g., Kusler, 1979; Strother, 1980; Whitley, 1982). Although some of these applications utilize computers for the analysis of inventory scores, creation of cognitive maps, and generation of learning prescriptions, the total management of the individualization process is manually controlled by teachers and staff. Similarly, Cavanaugh (1979, 1981) describes a diagnostic/prescriptive approach to individualization based on learning styles in a high school setting where the computer is only used to analyze learning style information and produce suggested prescriptions by subject for each student. The management functions of (a) monitoring and evaluating student performance on alternative treatments, and (b) formulating data into reports for students and teachers have generally not been computer supported in these individualization approaches.

That computer-based techniques can greatly enhance the management of individualization based on cognitive or learning styles has been recognized (e.g., Cosky, 1980), but to-date costs of computer equipment have made practical applications rare. The emerging microcomputer technology is rapidly changing these possibilities, however, and provides an opportunity to overcome problems associated with manual management of individualization and the resulting limitations to individualization. For example, without the aid of computer technology for diagnosing, prescribing, and evaluating student performance and progress, teachers must spend considerable time in administrative and clerical tasks associated with student management. In addition, complex decision making is difficult and refined matches of student cognitive style differences with alternative treatments are less likely to be based on updated student performance data. These limitations are particularly critical to the emerging science of individualization based on cognitive styles--a science that requires systematic analysis and decision making to revise and present a comprehensive learning environment with sufficient alternative treatments (Lindelow, 1983; Whitley, 1982).

As a final point, Lindelow (1983) has made a strong case for the position that simply matching treatments to a student's learning or cognitive style is not an adequate procedure. Rather, it is argued that the judgment and expertise of the educator/researcher should be used in determining how closely treatments and styles are matched. Lindelow (1983) recommends a matching approach which periodically exposes students to demands that do not precisely match their styles in order to develop their flexibility and ability to select appropriate strategies for particular learning contexts. The use of this more complex type of matching

strategy is particularly well suited for implementation within a computer-based management system.

The Use of Computers in the Management of Individualization

The development of computer management programs used in individualization of instruction has followed that of instructional computing in general. The first CMI systems were designed for large mainframe computers, most commonly on a timesharing basis. An example of an early research effort in CMI in the public schools is WIS-SIM (Wisconsin Student Information Management), a project undertaken by the University of Wisconsin beginning in 1972 (McIsaac & Baker, 1981). This program ran on a mainframe computer and stressed the grouping function of the management process in a variety of curricula. A concurrent study at the same institution involved a management system called MICA (Management of Instruction with Computer Assistance). This system emphasized the management functions of prescription and diagnosis, applied to the tracking of individual student progress independent of group progress.

In 1977, the University of Wisconsin began working on a microcomputer management system based on the earlier mainframe CMI efforts. This system, called MICRO-CMI, is designed to handle both the diagnosis and prescription functions of MICA, as well as the grouping capability of WIS-SIM (McIsaac & Baker, 1981). The program runs on a single microcomputer. The entire system includes the microcomputer, a printer, a sheet scanner, and disk drives (presumably two). As it has been implemented in the McFarland (Wisconsin) Public Schools, MICRO-CMI functions as a tool used by teachers primarily to recommend groupings of students for instructional purposes, and to generate a

variety of reports for teachers, parents, and students. As an example of its grouping capability, students in reading, math, and science are regrouped every two weeks. Compared to the 50 hours required for the manual regrouping of 200 students in reading, MICRO-CMI accomplishes the same job at a higher level of sophistication in less than an hour. Grades are the criteria upon which grouping and diagnosis decisions are made, where grades presumably refer to measures of mastery level of content or skill.

Two examples of large scale CMI systems for the management of individualization in military technical training are the Navy's CMI system (VanMatre, 1980) and the Air Force's Advanced Instructional System (AIS; McCombs & McDaniel, 1981). Both of these systems are implemented on large mainframe computers and both systems accommodate a wide range of management options including student diagnosis and prescription, progress monitoring and management, test scoring and evaluation, report generation, and resource management. The AIS also has the capability for complex individualization decisions based on adaptive decision rules which utilize both pre-course and within-course student information. In both the Navy and Air Force systems, printers and scanners are interfaced with the mainframe computer to provide a management terminal used for inputting student data and outputting student prescriptions and other management reports.

Several commercial computer firms have designed CMI systems to be used in the management of instruction. Control Data Corporation's (CDC) PLATO system and Hazeltine Corporation's TICCIT system are two well-known and widely used examples of commercially available CMI systems. Both of these systems were originally implemented on mainframe computers, but are currently being

converted to microcomputer-based systems. The currently available micro-PLATO capability involves a tie in to CDC's mainframe to handle management functions. A new version of TICCIT, MicroTICCIT, is now being marketed, however, which combines the authoring, delivery, and management of instruction through a micro network system. A third commercially available system is manufactured by WICAT Systems, Inc. WICAT's capabilities include the handling of CMI from several hardware configurations ranging from stand-alone to networked microcomputers.

Since the early 1980's, there has been a surge of interest in microcomputers and their application to instruction (Charp, 1982). There currently exists a large number of microcomputer firms (e.g., APPLE, Commodore, IBM) offering stand-alone systems at relatively low costs. Dramatic cost reductions from mainframe to mini to microcomputers have increased the use of computers in education. This phenomena, combined with the increased memory and storage capabilities of microcomputers, have increased interest in using microcomputers for more than the delivery of instruction, i.e., computer-assisted instruction (CAI). Microcomputers are now being explored for CMI application and can be effectively used in the management of individualization based on cognitive styles. The next section explores the range of management options to be considered in designing a microcomputer-based system that can manage cognitive style-based individualization.

Range of Management Options

In designing a management system to be implemented via microcomputer, two sets of options or requirements must be considered. This

section considers the first set of options, what functions are required by the management system itself; the following section describes the second set of options, what equipment is required.

Bozeman (1979, p. 51) has defined CMI as: ". . . management information systems designed to support certain management functions (e.g., planning, organizing, controlling) associated with individualization of instruction. The support of decision making, in particular decision making associated with the identification of the instructional needs of students and in the selection of the most appropriate instructional activities to meet these needs, is emphasized in systems of CMI."

The following list contains most of those functions which have been cited as desirable in a computer-based management system (Bozeman, 1979; McCombs, 1979; McIsaac and Baker, 1981):

1. Test administration
2. Scoring
3. Diagnosis
4. Prescription, or treatment recommendation and/or assignment
5. Automatic branching to on-line treatments
6. Performance evaluation
7. Report generation
8. Resource management and scheduling
9. Data base maintenance
10. System evaluation

Testing functions allow the system to administer a test or battery of tests to measure a student's entry level characteristics, including cognitive or learning style, as well as within-course performance.

Scoring includes the scoring itself and the storing of scores for later use in diagnosis and performance evaluation.

Diagnosis is defined as the assessment of a student's entry level characteristics based on information obtained from precourse test scores. Depending on the level of sophistication desired, diagnosis can also be extended to the assessment of students' within-course performance or alternative treatments.

Prescription involves either recommending or assigning the student to a particular treatment based on the previous diagnosis and predefined decision rules for matching student characteristics to treatment options, or to remediation based on individual performance evaluations and associated decision rules.

Automatic branching is a capability that can be used if treatments are provided on the computer in the form of CAI, wherein the management system could automatically branch to the prescribed on-line treatment.

Performance evaluation refers to the assessment of a student's level of mastery on particular treatments.

Report generation includes providing the instructor and/or researcher with individual student data such as test scores, cognitive style diagnoses, prescribed treatments, and progress reports. Summarized group data could also be available.

Resource management and scheduling is desirable in those applications where there are limited resources (i.e., less than the total number required to support all students needing a particular resource such as CAI, sound-slide devices, etc.), and/or when there is a linear sequence of course units (i.e., no flexibility in the order in which the units can be taken). If these conditions do not exist, the assignment to a particular resource can be analogous to the assignment to a particular treatment.

Data base maintenance is necessary in order for any computer-based management system to operate successfully, i.e., data bases must be initialized, updated, and maintained. Data bases most likely to be needed for cognitive style management are (1) a data base of student information, including entry level and course performance data, (2) a data base defining the course hierarchy of alternative treatments, (3) a data base containing the decision rule paran eters for each individualization decision, and (4) if resource management is included in the system, a data base containing the number and types of resources required for each course unit--to be used in determining resource availability.

System evaluation is a management option that consists of a built-in evaluation system to aid the implementor or researcher in determining the success of the prescribed treatments, and therefore, the appropriateness of the system's decision rules.

Some of these functions may be considered optional, depending on such issues as (1) whether the system will be used by instructors only, or by students as well, (2) the balance between research and practical implementation requirements, (3) level of financial and other support allocated for the system, and (4) the level of individualization to be addressed.

It should be noted that the management options discussed thus far have been in the context of CMI as defined by Bozeman (1979). In individualizing on the basis of cognitive style, the levels of individualization may range from gross cognitive style differences to very fine-grained ones. CMI is must capable of handling individualization at the gross level. As one approaches the finer distinctions of cognitive style, many of the management options listed above must be considered within the context of a particular lesson. This moves one away

from the realm of strict CMI, and toward CAI. In other words, within a particular treatment, a student may be tested, diagnosed, and branched to a subtreatment, all within the context of a single on-line lesson.

For example, if the overall management system determines that a student is a visual as opposed to an aural learner, it may make assignments to a treatment consisting of graphic-intensive CAI. That lesson may begin with a test to determine a finer level of style, say whether the student is a reflective or impulsive learner. If the student is reflective, the pacing of the lesson may be put under the student's control. If the student is impulsive, the pacing may be left under the control of the system in order to encourage the student to take more time to reflect on answers. Therefore, another consideration in determining management options is how finely one wishes to distinguish cognitive style differences, so that one will know whether management options should be considered only on a broad scale, only on a fine scale within lessons, or both.

In summary, the designer must determine which management functions and what level of individualization are necessary or desired in order to evaluate the second set of options or requirements, those relating to computing hardware.

Range of Equipment Options

The simplest, least expensive type of hardware system that could handle CMI at some level would be a single microcomputer used in a manner similar to that of the MICRO-CMI project described earlier (McIsaac & Baker, 1981). It should be noted that this type of system would be a tool used only by teachers or research staff. Although the microcomputer would certainly be capable of administering tests and presenting CAI, it would be impractical to attempt to use a single machine to test and present instruction to an entire class of students.

Tests would be administered manually, and scores entered into the computer program's data base either manually at the keyboard or automatically by means of a scanner. Once the data bases are initialized in this manner, the system would be able to manipulate the data in just about any prescribed way. The MICRO-CMI system was reported to have the capability to store data on 1,000 students on a single diskette, and through swapping diskettes, do calculations on a population as large as 1,000. The major functions involved in management of individualization, diagnosis of individual need and prescription of instruction to meet that need, could be handled by a single microcomputer. Implementation of prescribed instruction would have to be handled off-line.

The major disadvantages of using a single microcomputer for CMI are matters of inconvenience. It would involve quite a bit of diskette swapping, it would require a relatively long compute time compared to larger systems, and it would be limited to one user at a time. The major advantage is that a single microcomputer will do the job of managing instruction, or actually recommending management strategies to be implemented, at a much more sophisticated level than would be possible manually, for the price of a single system. MICRO-CMI reported a cost of $15,000 for initial aquisition and $2,000 per year for operating costs, for a total of $25,000 for a 5-year period.

Combining several microcomputers together in a network can offset some of the disadvantages of using a single machine. The obvious advantage is that a network is a multi-user system. This means that the management system could take on the function of test administration. Having tests administered on-line would mean faster and more efficient scoring and data base updating. It is possible that a network of this kind could be used to present CAI as well.

However, if one wants an overall management system in operation that would control the presentation of CAI, and update the data bases with information from the lessons automatically, one would need to consider an addition to the network that would provide greater storage capability.

A network of microcomputers that shared a hard disk drive would be such a system (Charp, 1982). The increased storage capability of hard disks would mean that the management system itself, including its data bases, could be available at all times, even during the presentation of CAI lessons that might be loaded separately from floppy disk drives at the individual work stations. Other advantages of increased storage capability is the possibilities of more sophisticated decision rules, the handling of resource management, and the implementation of system evaluation functions. Of course, one would still be limited by the storage capability of an individual computer. It can manipulate only as much data as it can hold at any given time. This means that some functions, such as the system evaluation for research purposes, would need to be handled during a time when the system was not managing students directly. A final advantage of having a hard disk drive is a matter of convenience again. Diskette swapping could be eliminated or at least greatly reduced.

Several computer companies are now coming out with microcomputer network systems specifically designed for the training environment. For example, Hazeltine's MicroTICCIT is a system of microcomputers which shares a hard disk for storage of student records, courseware, and system software, including a management system, and a host processor with 256K bytes of usable memory for processing. This type of system addresses the problem of using microcomputers to handle complex management tasks without dependence on an expensive minicomputer.

Issues in the Implementation of Microcomputers for the Management of Individualization

Issues in two general areas are of relevance to the implementation of microcomputers for the management of individualization based on cognitive styles. First, it is important to clearly distinguish between what is meant by the management of individualization and the actual presentation of individualized treatment alternatives within the framework of microcomputer-based systems. For the purposes of this presentation, this distinction reduces to using the computer as a management tool vs. only for the presentation of instruction, i.e., CMI vs. CAI. Because microcomputers can be used in either capacity and management functions can be performed in both CMI and CAI applications, it is necessary to determine which application is most suitable to the management of individualization. This is particularly true if the individualization desired involves more than computer-based, on-line treatments and makes use of off-line treatments as is likely to be the case when individualizing to accommodate cognitive style differences. As has been suggested earlier, a basis for deciding whether a CAI or CMI approach to the management of individualization is most appropriate in the adaptation to cognitive style differences, is to determine whether gross or fine-grained treatment alternatives are required to meet the needs of a particular student population and content area.

Second, it is important to keep in mind that the management of individualization can be addressed in both the context of classroom implementations and the context of research and development. Ideally, however, both contexts should be considered such that even in a pure classroom implementation, research and evaluation components are present, and likewise, in

a pure research and development context, classroom implementation issues are addressed. Consideration of this issue is particularly important given the current status of research in cognitive styles and the need for further experimentation and exploration of research questions (Ragan, Back, Stansell, Ausburn, Ausburn, Butler & Huckabay, 1979) . In addition, incorporating research and practical implementation concerns in a microcomputer system for the management of individualization increases the likelihood that management and individualization decisions will have both practical relevance and empirical validity.

The preceding issues have implications for the sophistication needed in a microcomputer-based system for the management of individualization based on cognitive styles, as well as concomitant implications for the selection of particular microcomputer systems and configurations. In turn, these implications have to be considered in light of practical realities in the implementation setting. That is, both the degree of sophistication and type of microcomputer system required for the desired management approach must be considered in light of such practicalities as available resources, staff commitment, etc. As Lindelow (1983) has pointed out, individualization efforts based on cognitive style or learning style are likely to fail if the approach is too demanding, costly or difficult, if teachers are not capable or committed enough, if the individualization philosophy is misunderstood or not implemented properly, or if insufficient funds are available.

For the foregoing reasons, therefore, it is critical to involve personnel who will be part of the implementation and evaluation of the management system in the design and development of this system. McIsaac and Baker (1981) have recommended a pilot project approach wherein users can be involved in the design and development of the individualization as well as its management. Such an

approach can lead to greater system acceptance and commitment to its successful implementation, as has been noted in efforts to individualize on the basis of cognitive styles (e.g., Cavanaugh, 1979, 1981; Ellis, 1979; & Epstein, 1981).

In conclusion, the management of individualization based on cognitive styles is a complex but realizable solution to the problem of accommodating individual differences, when implemented with current computer-based technologies. The use of microcomputers for this management promises to provide both a practical and cost effective approach to maximizing student learning and motivation.

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